THE FLASH SPECTRUM.

By S. A. MITCHELL.

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The total eclipse of 1918 saw the completion of fifty years since the spectroscope was first used at the eclipse of 1868, visible in far-off India. If all the minutes of totality during this half century of eclipses were added together, they would amount to less than one brief hour. It is safe to say, however, that no other branch of astronomy has shown the remarkable value of the new instrument of research as has the work of eclipse spectroscopy.

In 1868, Janssen discovered that the prominences gave a bright line spectrum thus proving that they are gaseous in nature. As is well known, he and also Lockyer independently, showed how to view the prominences without an eclipse.

The year 1869 brought with it the discovery of helium in the sun. Since the urgency of the war has resulted in having helium supplied in such large quantities and at such a cheap price that it may be used in balloons and airships, it is almost a surprise to think that helium was not discovered by Ramsay until the year 1895.

The eclipse of 1870 visible in Spain is noted for the discovery of the flash spectrum. The dark lines in the solar spectrum, the Fraunhofer lines are caused by the absorption of the light of the photosphere by a thin layer of cooler gases, the so-called reversing layer. This layer is cool only in contrast with the very hot photosphere. As the moon gradually covers the sun at the time of an eclipse the dark line spectrum persists so long as there is even the slightest trace of the photosphere visible. At the instant when the photosphere is entirely covered up, the bright photospheric background of the Fraunhofer spectrum is removed, and the lines of the spectrum now appear as bright lines on a black background, where before there had been dark lines on a bright background. This change coming with totality was foretold by Young of Princeton before the eclipse of 1870, and his was the first eye to perceive it. The suddenness of the change caused him to name the bright line spectrum the "flash spectrum." At the beginning of totality, the flash spectrum lasts for only a few seconds while the moon is advancing in front of the rather shallow layer. A second flash spectrum is seen at the end of totality.

The first attempt to photograph the flash was in 1893, but with very imperfect results. Shackleton in 1896 was more successful, though the first photographs with good definition were those of the eclipse in India in 1898 by Evershed.

In the year 1900, the American astronomers had an opportunity in their own country at the eclipse of May 28. For the first time in eclipse work, Rowland gratings were used. Gratings are ruled on both plane and concave surfaces, and it is possible to use them either with or without a slit. The great advantages of gratings over prisms are the increased dispersion, but particularly their normal spectrum. When used in the ordinary Rowland mounting, the concave grating shows marked astigmatism. Although work on stars had shown that the astigmatism of the concave grating when used directly without slit was exceedingly small, most observers in 1900 were apparently afraid to use a concave grating without a slit. Those who did use slits found their photographs entirely without lines, the light that went through the slit being entirely too feeble to leave any impression on the photographic plate. Gratings used without slits gave more satisfactory results.

Since 1900, the eclipses most easily observed were the Sumatran eclipse of 1901, the Spanish eclipse of 1905, the Flint Island eclipse of 1908, the Russian eclipse of 1914, and the American eclipse of 1918.

When great dispersion is desired, the concave grating without slit is perhaps the most desirable form of spectrograph. Its mounting is very simple. Light from the cœlostat mirror falls direct on the concave grating where it is diffracted and brought to a focus on the photographic plate. It might not be out of place here to call attention to the great importance, and also the great difficulty, of obtaining sharp focus with the slitless instrument. The best results have been obtained by the writer through the use of a collimator designed by Jewell.

In 1905 with a Rowland concave grating of 15,000 lines per inch, Mitchell secured a photogrph of the flash spectrum in which he measured 2,841 lines between λ 3300 in the violet, and the D_3 line in the yellow. On account of the good definition, it was possible to determine wave-lengths to 0.02 Ångstroms corresponding to an error of measurement of 0.002 mm.

The general conclusions from these measures were:

1. The flash spectrum is a reversal of the Fraunhofer spectrum.

2. The flash is not an instantaneous appearance, but the chromospheric lines appear gradually. At the beginning of totality, those of greatest elevation appear first, and at the end of totality remain the last. The "reversing layer" which contains the majority of the low-level lines is about 600 km. in height.

3. Wave-lengths in the chromospheric and solar spectrum are practically identical.

4. The lines in the chromospheric spectrum differ greatly in intensities from the lines in the solar spectrum. The chromospheric spectrum shows the hydrogen series of lines and the helium lines and corresponds to a spectral type earlier than the solar spectrum.

5. The differences in intensities find a ready explanation in the heights to which the vapors ascend.

6. Especially prominent in the chromosphere are the enhanced lines.

In view of the very excellent work done recently at Mt. Wilson, it has become of the utmost importance to have as accurate a knowledge as possible of the heights of the various layers of the sun's chromosphere above the photosphere. There is no other method of determining these heights directly except from the photographs of the flash spectrum at the time of a total eclipse taken without slit. By knowing the angular diameters of sun and moon, it is easy to calculate the height of the solar layers of atmosphere by measuring the lengths of the cusps. On the photograph a spectrum line of considerable length corresponds to a greater height of atmosphere, while a shorter line belongs to a low-lying vapor.

The program of work on the flash specrum at the eclipse of 1918 was for the purpose of finding the heights of the various gases, and also of extending our knowledge of the spectrum as far into the red as possible. The Naval Observatory party located in Baker, Oregon, had three concave gratings, the largest being of 21½ feet radius and 15,000 lines in order to procure as large a dispersion as possible; the second grating was of 10 feet radius and 15,000 lines, while the third was of small dispersion to photograph into the extreme red by the use of plates stained by dicyanin. Unfortunately, thin clouds covered the sun during the whole of totality. The clouds at the end of totality were exceedingly thin, but they were sufficient to cut out most of the weaker lines from the spectra. At no place in the country where photography of the flash spectrum with great dispersion was attempted did clear skies prevail; and consequently the carefully prepared plans for 1918 will have to be tried again at the next available eclipse.

McCormick Observatory,
University of Virginia.